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REPORT NO. RR-TR-63-13

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ATMOSPHERIC ENVIRONMENT FOR PERSHING MISSILE 403

15 April 1963

U S ARMY MISSILE COMMAND
REDSTONE ARSENAL, ALABAMA

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ATMOSPHERIC ENVIRONMENT FOR PERSHING MISSILE 403

by
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ABSTRACT

This report presents the atmospheric environment for the flight of PERSHING Missile-403, which was launched on 14 February 1963, at 1945 EST, from the Atlantic Missile Range, Cape Canaveral, Florida. The general synoptic situation for the flight area, surface observations at launch time, and upper air conditions as measured by rawinsondes released as close to missile launch time as possible are given. High altitude wind data over the launch area as determined from a meteorological rocket flight are also presented.

Relative deviations of thermodynamic quantities from the Patrick Air Force Base Annual Reference Atmosphere are presented in graphical form for easy reference.

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LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (Concluded)

SYMBOLS, UNUSUAL TERMS AND NON-STANDARD ABBREVIATIONS

C	-	degree Celsius
K	-	degree Kelvin or absolute
kg	-	kilogram
kp	-	kilopond - kilogram force
km	-	kilometer
m	-	meter
mb	-	millibar
mps or m/sec	-	meters per second
T-0 or T-Time	-	missile launch time
n	-	index of refraction
W_{S-N}	-	meridional wind component
W_{W-E}	-	zonal wind component
W_x	-	range direction wind component relative to missile flight path
W_z	-	cross-range wind component relative to missile flight path
T^*	-	virtual temperature
θ^*	-	virtual-potential temperature
GCT or Z	-	Greenwich civil time
Standard	-	refers to the Patrick Air Force Base (PAFB) Reference Annual Atmosphere

ATMOSPHERIC ENVIRONMENT FOR PERSHING MISSILE-403

I. INTRODUCTION

This report presents the more important portions of available atmospheric information pertinent to the missile flight at 1945 EST on 14 February 1963, from Cape Canaveral, Florida. Surface and upper air observations were made as close to missile launch time as possible at the launch site and downrange at Grand Bahama Island.

Rocket measured winds were determined from radar track of a LOKI II meteorological rocket flight provided by the PAFB Air Weather Service in support of PERSHING Missile-403.

This information is presented to document in detail the atmospheric conditions prevailing at time of missile launch and to provide supporting material for specific atmospheric investigations in connection with missile design and/or missile flight-mechanical performance studies.

II. PRESENTATION AND DISCUSSION OF DATA

A. Source of Data

The general synoptic situation was taken from weather maps made by the U. S. Weather Bureau on missile firing date (Figs. 1, 2, and 3) and from data furnished by the Patrick Air Force Base Weather station.

Surface and upper air observations were made at the Cape Canaveral launch site and downrange stations under the supervision of the U. S. Air Force. These observations were made as close to the missile launch time as possible.

A LOKI II meteorological rocket furnished by the U. S. Air Force was fired in support of Pershing Missile-403.

B. Methods of Computation and Presentation

Wind speed and direction, temperature, pressure, and relative humidity are measured by rawinsondes. Thermodynamic quantities are computed from the rawinsonde data by use of the hydrostatic equation and its modifications as given in the Smithsonian Meteorological Tables (Ref. 1). Thermodynamic values are then determined for each 250 meters of altitude above sea level by interpolation.

Wind data are also interpolated at 250 meter intervals of altitude using the altitude references computed from the hydrostatic equation. Rawinsonde wind data are considered unreliable at high altitudes and low elevation angles (less than 10°). Wind shears are computed for each 250 meter interval of altitude from the rawinsonde data.

Temperatures are fitted by logarithmic interpolation between the ceiling of the rawinsonde temperature curve and the ARDC temperature curve of 9.5C (282.66K) at the 1 mb pressure height. Tabulated ARDC temperatures are used above the 1 mb pressure level and density is computed as before.

The index of refraction is computed by use of the formula given in "Analysis of Refractive Index Errors", by Epstein (Ref. 2).

The rawinsonde measured atmospheric parameters are compared to the Patrick Air Force Base Reference Atmosphere (Ref. 3), by subtracting the reference atmosphere values from the rawinsonde values at corresponding altitudes.

C. General Synoptic Situation at Missile Firing Time

A very flat high pressure ridge extended from the vicinity of Brownsville, Texas across the Gulf of Mexico and southern Florida. A 1033 mb high was centered over northeastern North Dakota with a ridge extending south-southeastward. This immense high covered the entire eastern two-thirds of the United States north of a cold front which extended from a weak low (1002 mbs) over Massachusetts southwestward over eastern North Carolina, through central Georgia, southern Louisiana to southeast Texas where it became stationary and extended to the north-northwest along the eastern slopes of the Rockies. This front was very weak through the Carolinas to southern Louisiana with no associated clouds. Cloudiness over Florida during countdown and launch consisted of a few scattered stratocumulus through central and south Florida with patchy middle and high clouds over the Keys. Surface winds were west-southwesterly with speeds of 5 m/sec or less. Visibilities were 10 miles or more. Impact area conditions were clear to scattered cumulus with some patches of thin cirrus.

Winds aloft were WNW to W up to 4 km; above 4 km winds were west-southwesterly to approximately 21 km above which they became variable. Maximum speeds of 73 m/sec were observed at the 9.75 to 10.25 km levels in the upwind release.

D. Surface Weather Observations

This information is given in the table on page 3.

SURFACE WEATHER OBSERVATIONS

Location	Time		Date 1963	Temperature °C	Relative Humidity %	Pressure mb	Wind		Clouds and Weather
	GCT	Missile					Direction	Speed	
Cape	0045	0000	15 Feb	11.1	81	1021.0	W	3.1	2 CI*
GBI	0045	0000	15 Feb	12.8	93	1021.7		Calm	Clear

* Cirrus Clouds

SCHEDULE OF UPPER AIR OBSERVATIONS

Location	Starting Time		Date 1963	Duration of obs min	Maximum Wind			Maximum altitude km
	GCT	Missile			Direction	Speed mps	Altitude km	
Cape* (Rawinsonde)	*	*	15 Feb	*	WSW	73	9.75 10.25	31.5
GBI (Rawinsonde)	2350	-0055	14 Feb	103.0#	WSW	78	9.75	28.75
Cape (Meteorological Rocket LOKI II)	0145	+0100	15 Feb	14.5	W W	36.5 45.5	43.5 53.0	54.0

* Surface to 8 km wind measurements at Cape Weather Station at 0150Z starting time. 8 km to 23 km measurements at St. Cloud remote release point, 242 degrees, 42 miles from Cape at 0039Z starting time.

23 km to 31.5 km measurements at Cape Weather Station 0340Z starting time.

\# Doubtful wind data above 10 kilometer altitude.

E. Upper Air Observations

1. Schedule of Upper Air Observations

This information is given in the table on page 4.

2. Wind Data

Launch site and downrange wind data are shown in Figures 4 and 5. Surface winds were west at 3.1 m/sec at the Cape and were calm at GBI. Winds aloft at both the Cape and GBI were west-northwest by 2 km altitude and backed slowly to become west-southwest by 10 km altitude. Reliable wind data terminated at 11 km altitude for GBI. Wind direction at the Cape continued from west-southwest from 10 km to 20 km and was variable from there to termination of the data at 30.75 km altitude. Maximum wind speed at the Cape was 73 m/sec at 9.75 km and 10.25 km altitude. GBI had a maximum wind speed of 78 m/sec, also at 9.75 km altitude.

The wind components are shown in Figures 6 and 7. A tailwind from the right was observed from the surface to 21 km at Cape Canaveral and was variable in both the range direction and cross-range components above 21 km altitude. At GBI tailwinds from the right were observed from just above the surface to termination of reliable data at 11 km altitude. Maximum range direction wind component at the Cape was a tailwind of 57.2 m/sec at 11.5 km altitude.

The rawinsonde measured wind shears computed at even altitude increments of 250 meters each are shown in Figure 8.

Wind data computed from radar data for the meteorological rocket flight are shown in Figures 9 and 10. Two maximum speeds are shown in the data. One at 43.5 km altitude of 36.5 m/sec and another at 53 km altitude of 45.5 m/sec. The data above 50 km are questionable.

3. Thermodynamic Quantities

Rawinsonde measured ambient temperatures (Fig. 11) were below the PAFB standard atmosphere at both the Cape and GBI from the surface to 11 km altitude (Fig. 12). From 11 km to near 14 km temperatures were above standard at both stations. It was below standard from there to termination of the data for GBI. The Cape had another above-standard layer near 20 km, but with that exception was below the standard from near 14 km to termination of the data. Maximum temperature deviation from the PAFB standard was 4.7 percent below standard at 1.25 km altitude for the Cape and 4.0 percent below standard at 17.5 km for GBI.

Pressure at both the Cape and GBI was below the standard at all altitudes from 1 km to termination of the data (Fig. 12). Maximum deviation was at the highest altitude reached; 31.5 km at the Cape with 5.7 percent below standard, and 28.75 km at GBI with 6.4 percent below standard.

Density was above the standard from the surface to 6.5 km at Cape Canaveral (Fig. 12). From there to termination of measured data density was below the standard. Maximum deviation of 5.8 percent above standard was measured at the surface at Cape Canaveral. The maximum density deviation for GBI was 3.6 percent above standard at 1.5 km altitude.

The virtual potential temperatures for the Cape and Grand Bahama Island are shown in Figure 13. Figure 14 shows temperature lapse rates for the Cape.

Relative humidity (Fig. 15) was slightly lower than that in the reference atmosphere from the surface to 500 meters altitude for both the Cape and GBI. An increase in moisture content began at near 500 meters and by 1.25 km altitude relative humidity at the Cape was near the reference atmosphere while that at GBI was above. Above 2 km the relative humidity remained below 20 percent except for a moist layer near 9 km altitude at GBI where it went above 65 percent.

The index of refraction for Cape Canaveral and Grand Bahama Island is shown in Figure 16. The Reference Atmosphere for PAFB is shown in Figure 17. Absolute deviations of the index of refraction (Fig. 18) for the Cape and GBI follow similar patterns, but with the largest deviations being at the Cape; $(n-1)10^6 = 44.5$ units below the reference atmosphere at 1.75 km altitude.

III. CONCLUSIONS

Surface winds at the Cape at launch time were westerly 3.1 m/sec. Winds increased in speed aloft to become 73 m/sec at 9.75 km altitude.

Scattered cirrus clouds were reported at the Cape and clear skies at Grand Bahama Island.

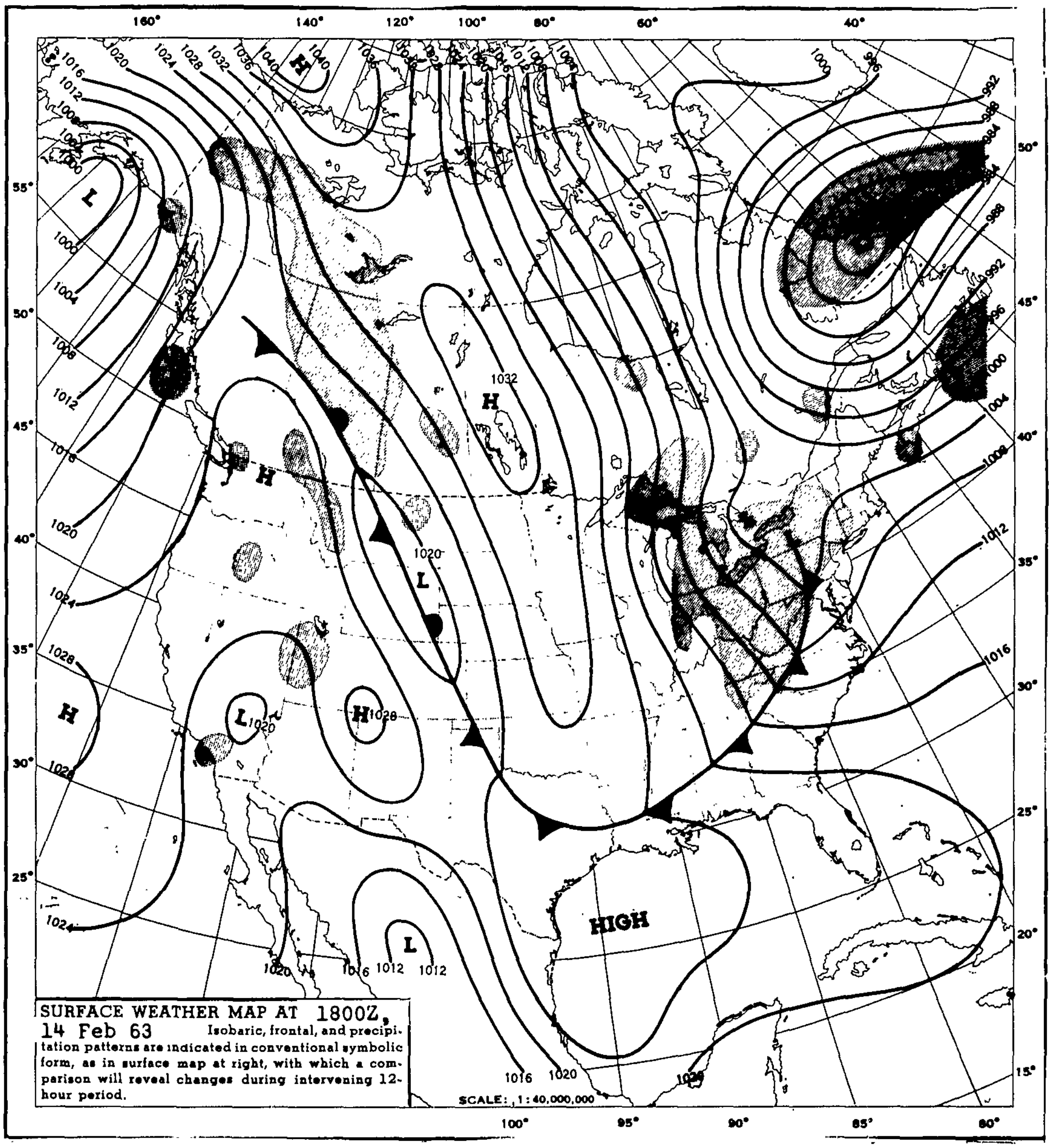

Figure 1. SURFACE WEATHER MAP AT 1800Z, 14 FEBRUARY 1963, 0645 PRE-T

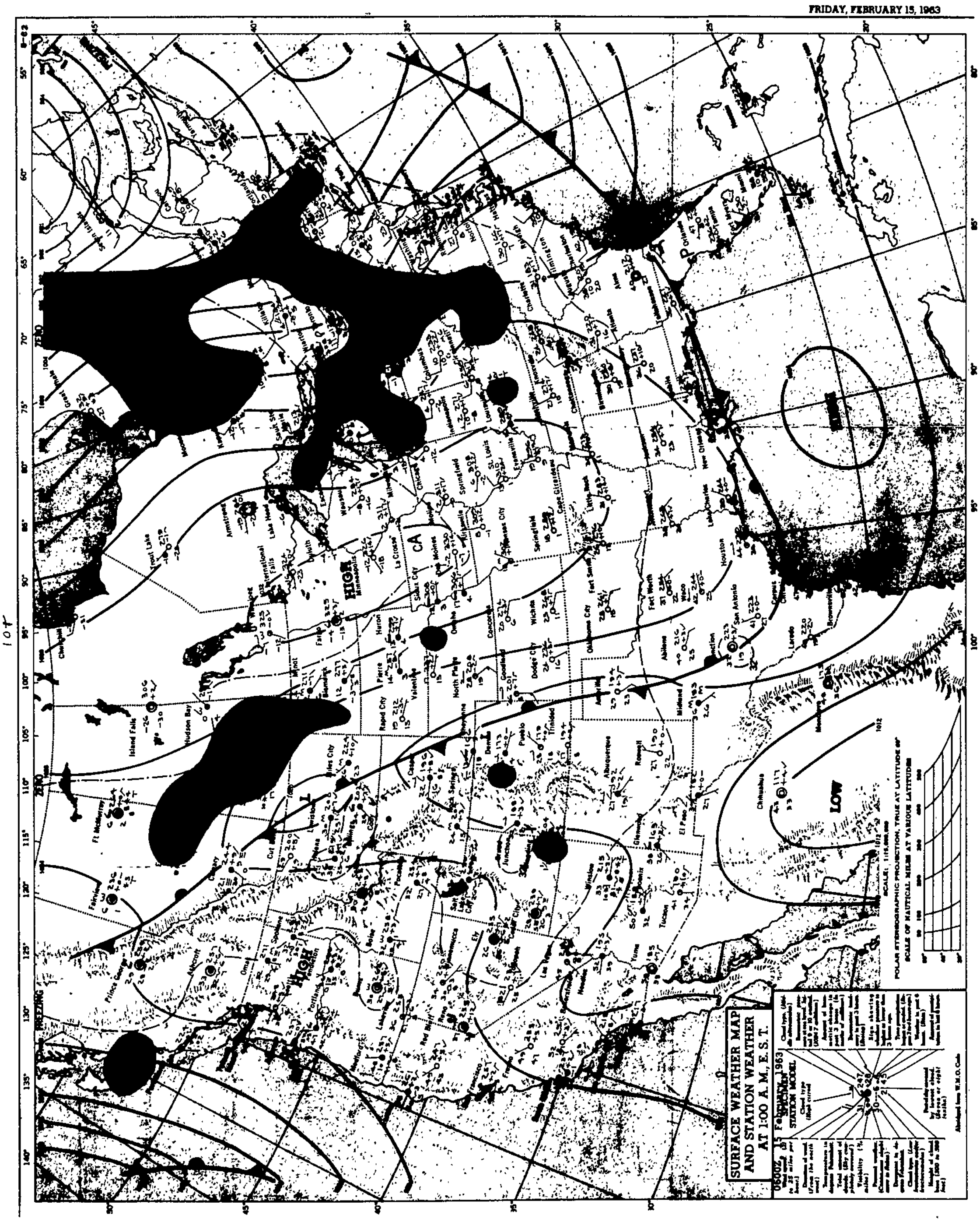

Figure 2. SURFACE WEATHER MAP AT 0600Z, 15 FEBRUARY 1963, 0515 POST-T

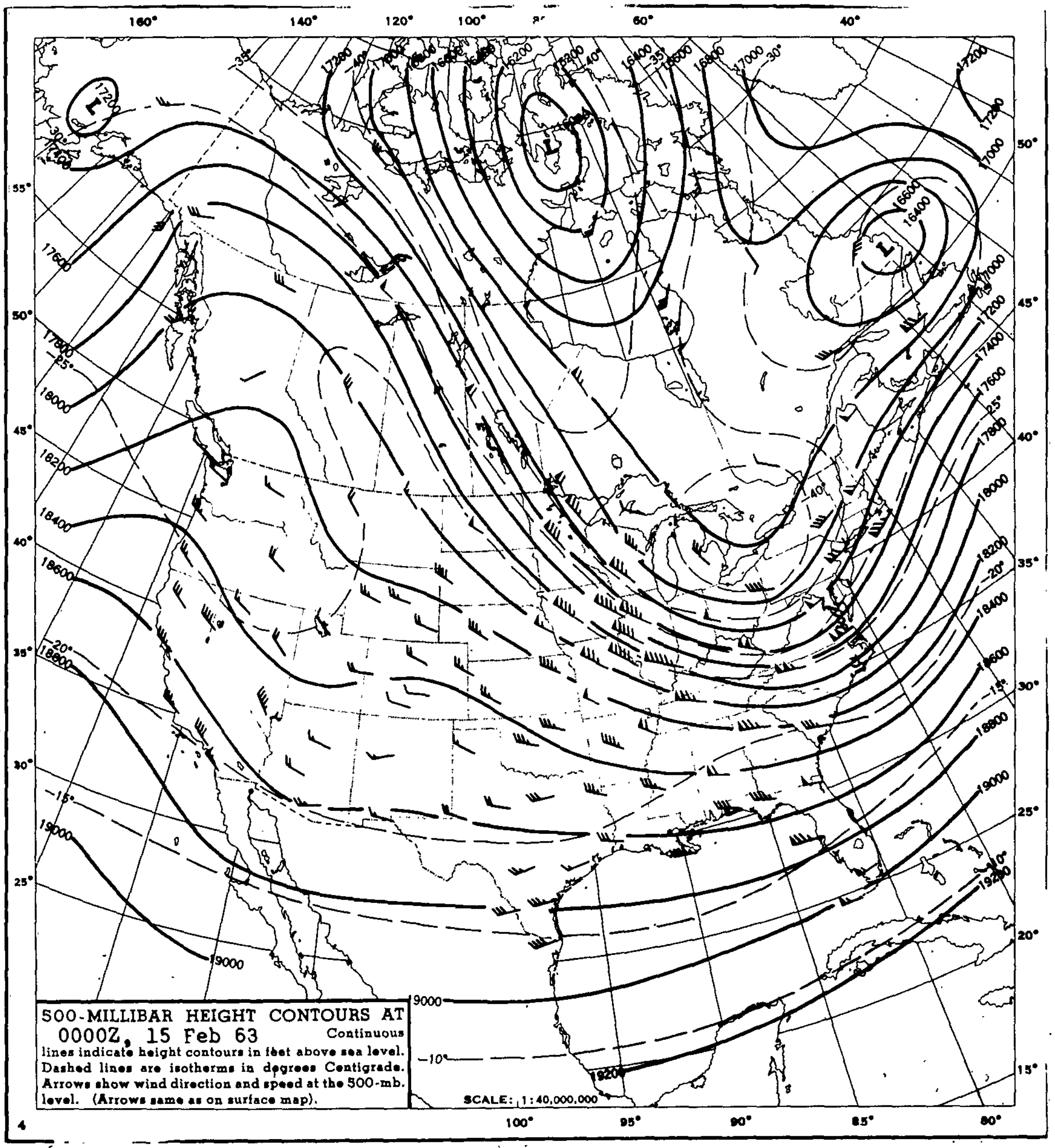

Figure 3. 500-MILLIBAR HEIGHT MAP AT 0000Z, 15 FEBRUARY 1963, 0045 PRE-T

ATMOSPHERIC PARAMETER CHART
No. 3

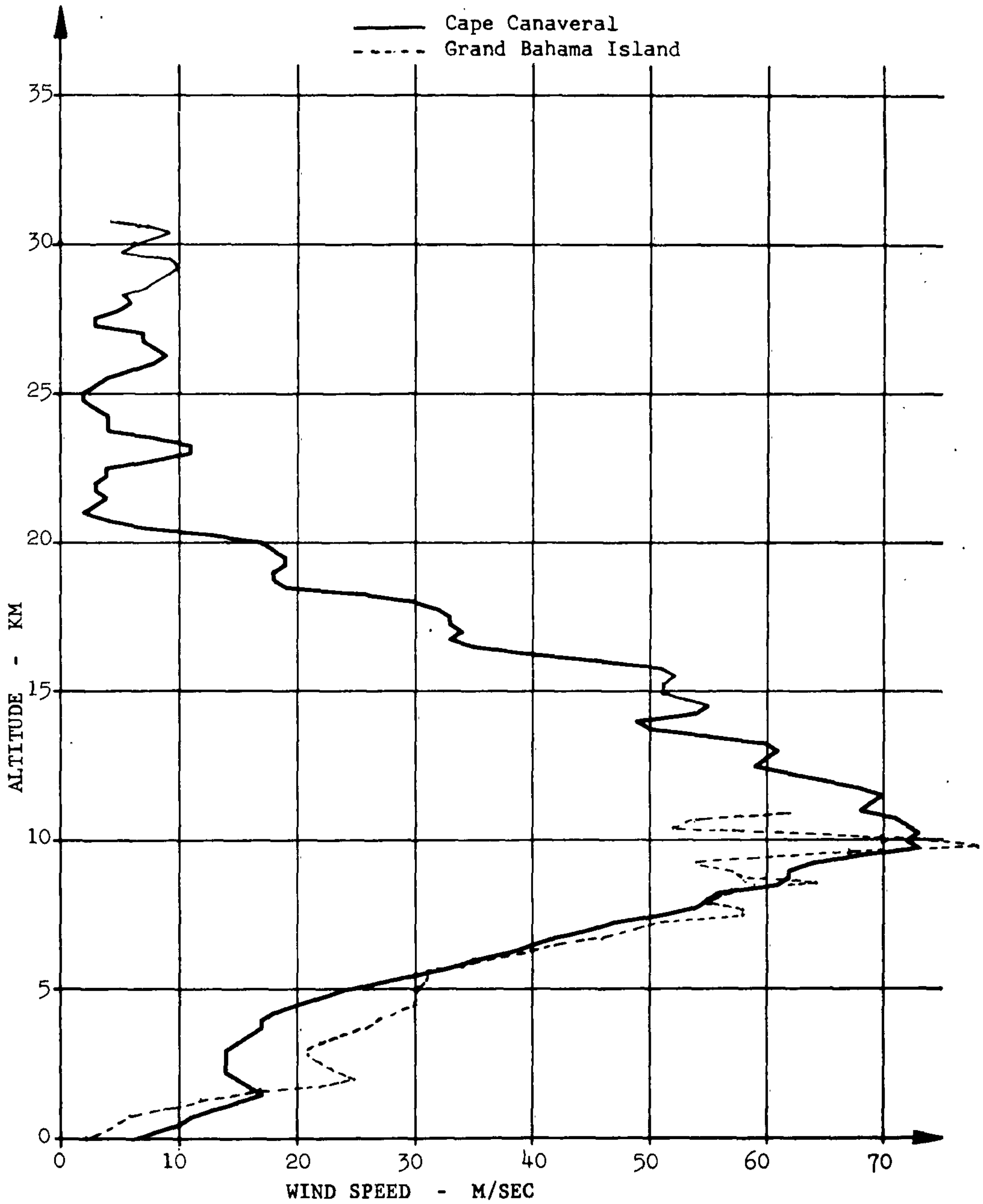

Figure 4. RAWINSONDE MEASURED WIND SPEED, CAPE CANAVERAL, FLORIDA, AND GRAND BAHAMA ISLAND

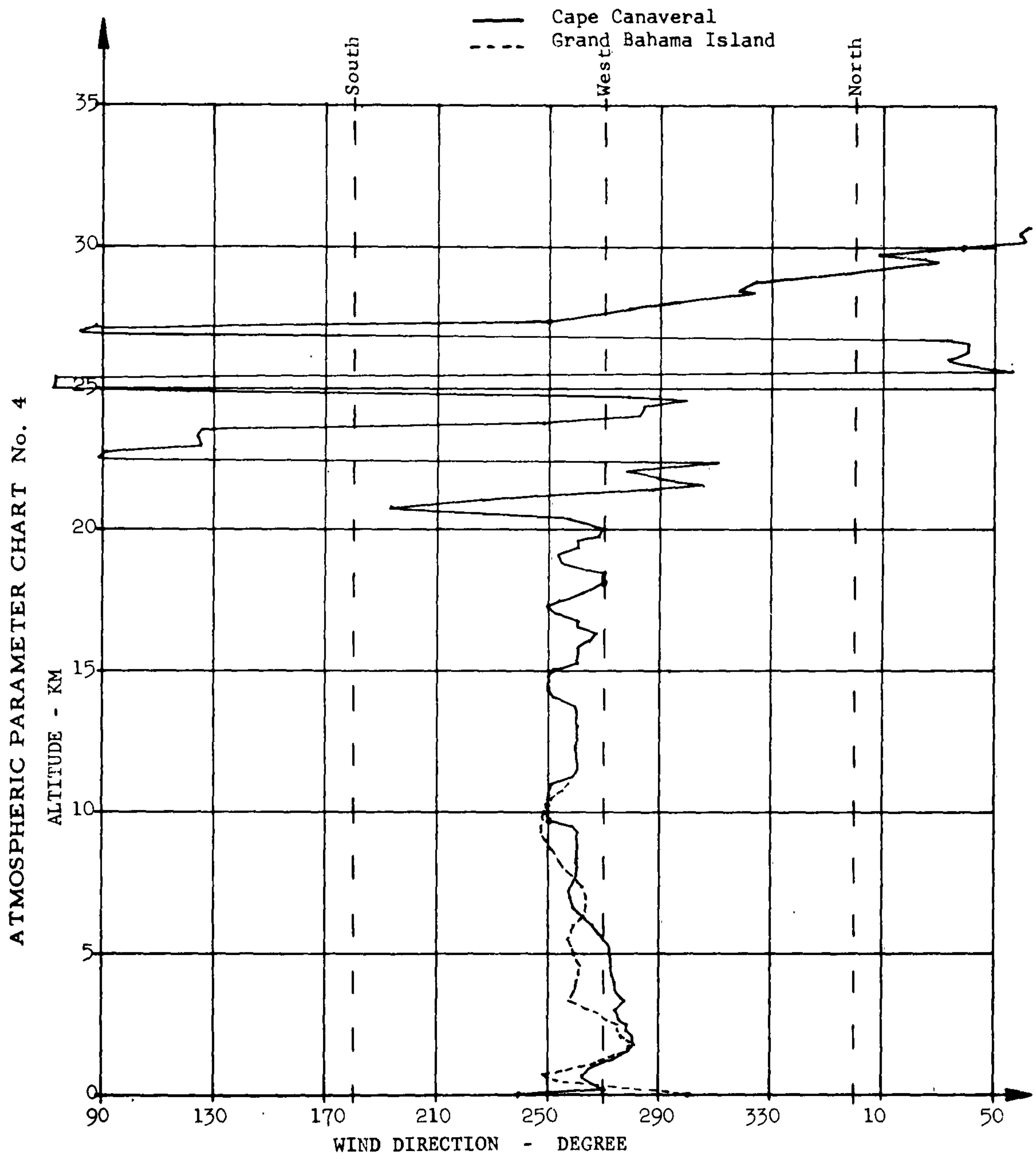

Figure 5. RAWINSONDE MEASURED WIND DIRECTION, CAPE CANAVERAL, FLORIDA, AND GRAND BAHAMA ISLAND

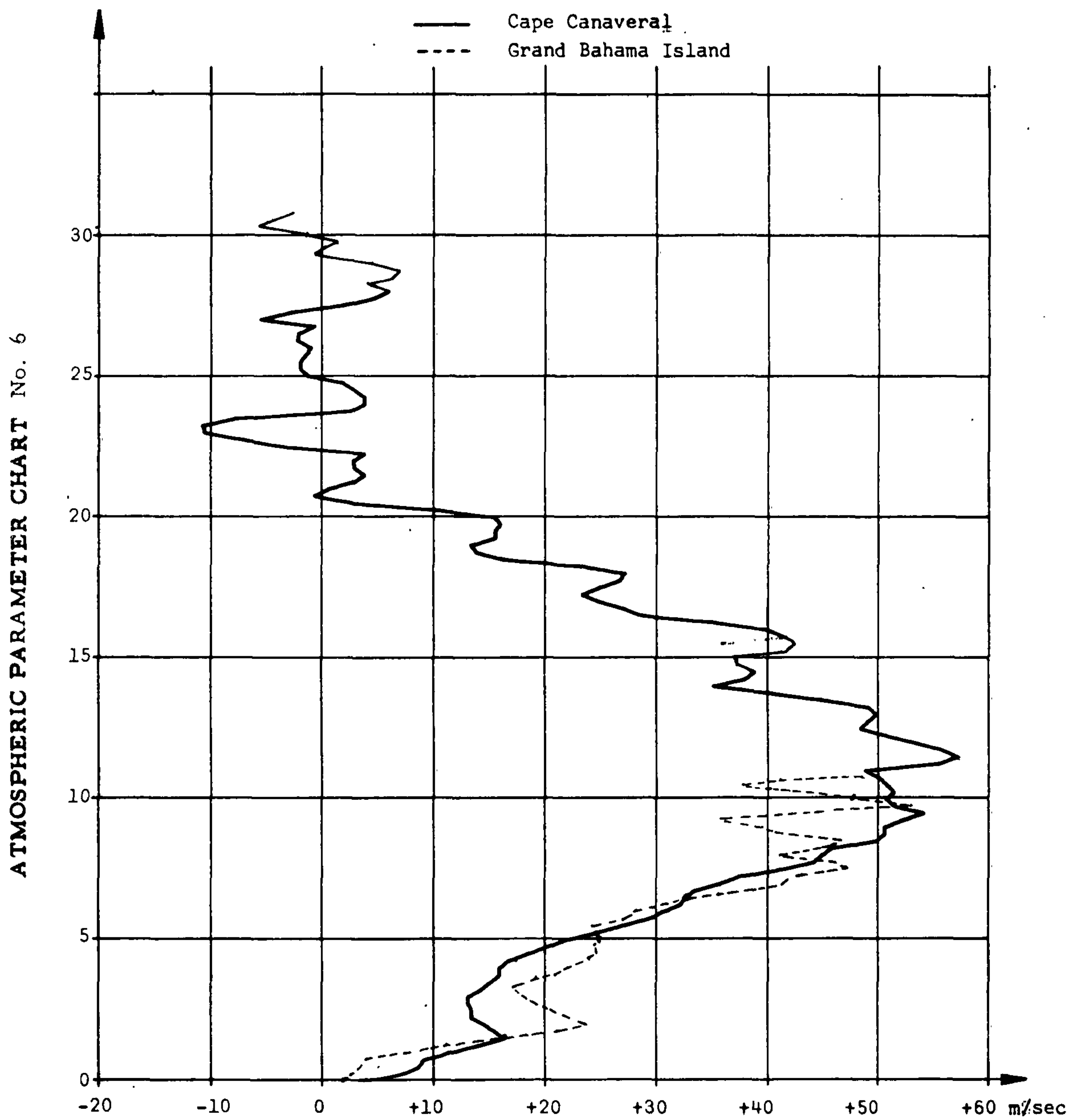

Figure 6. RANGE DIRECTION WIND COMPONENTS (W_x), CAPE CANAVERAL, FLORIDA, AND GRAND BAHAMA ISLAND

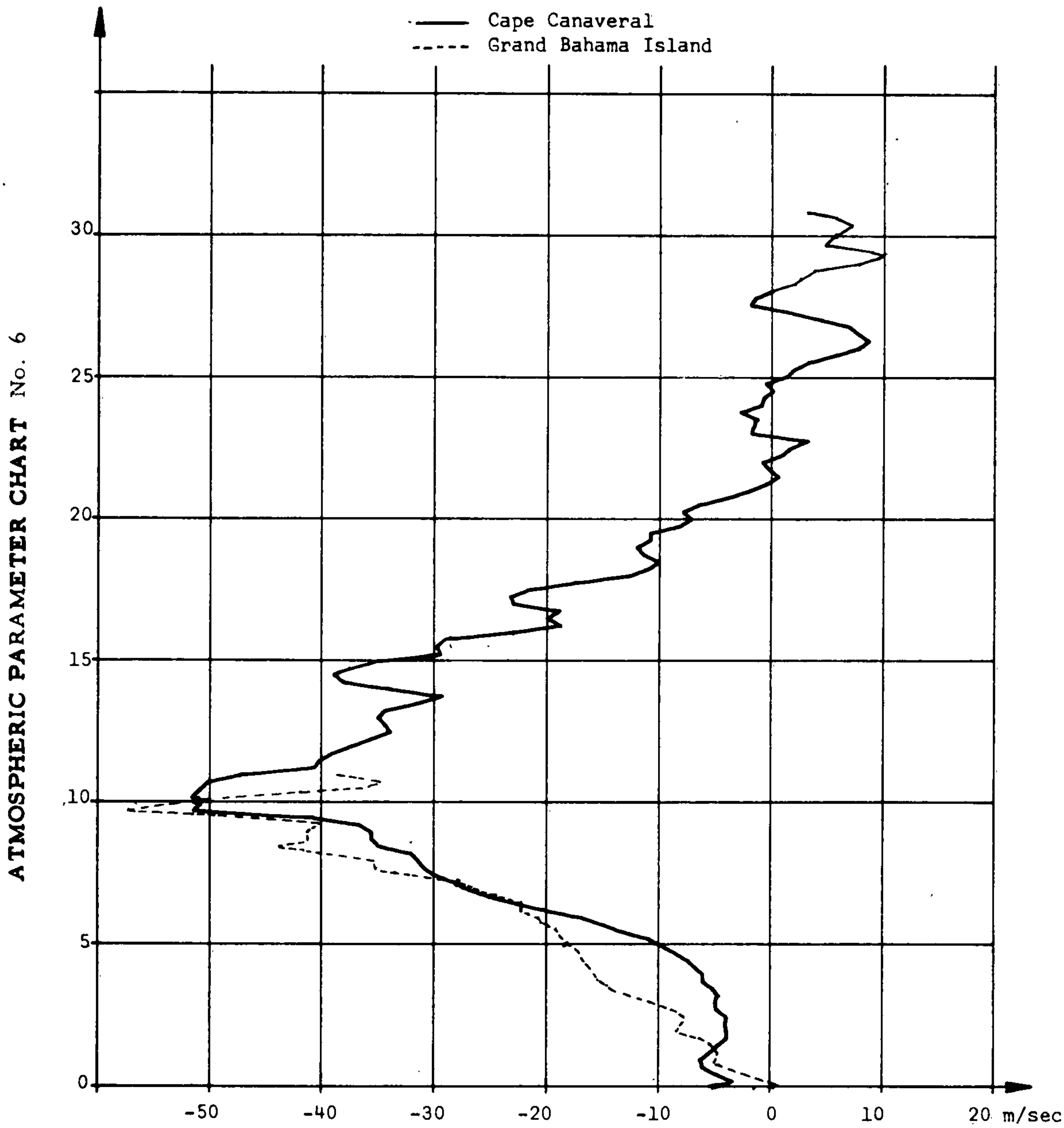

Figure 7. CROSS-RANGE WIND COMPONENTS (W_x), CAPE CANAVERAL, FLORIDA, AND GRAND BAHAMA ISLAND

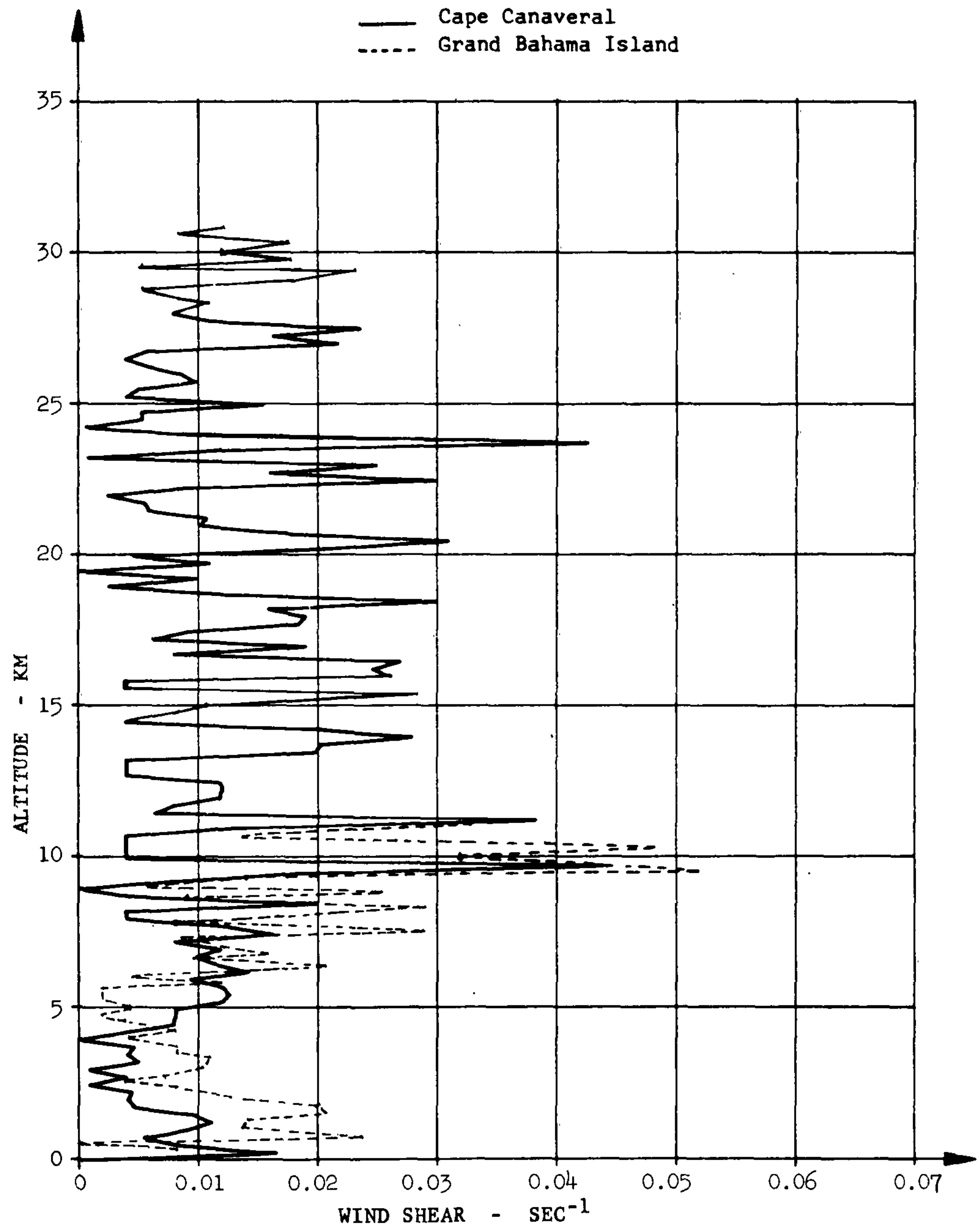

Figure 8. RAWINSONDE MEASURED WIND SHEARS, CAPE CANAVERAL, FLORIDA, AND GRAND BAHAMA ISLAND

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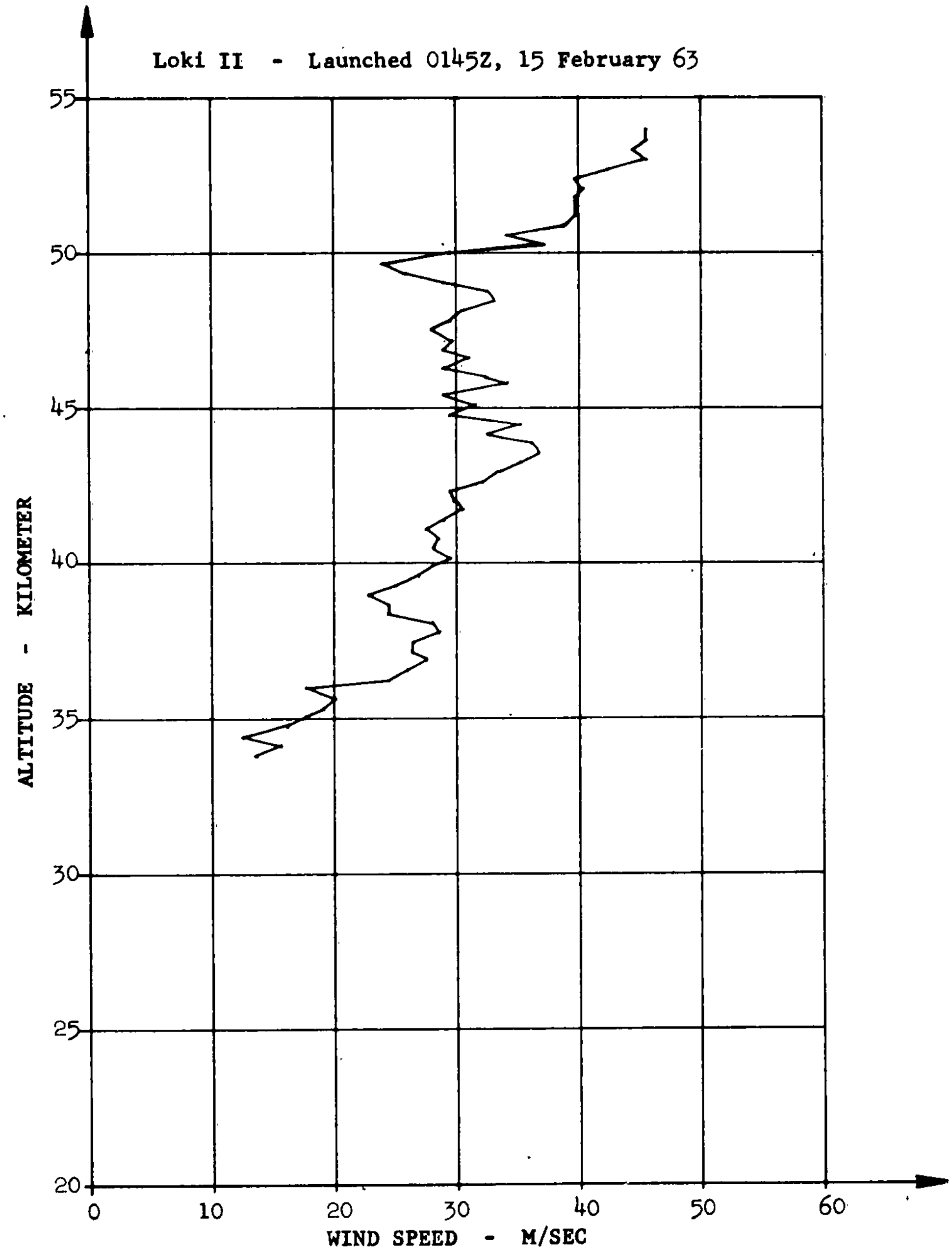

Figure 9. WIND SPEED, METEOROLOGICAL ROCKET MEASURED, CAPE CANAVERAL, FLORIDA

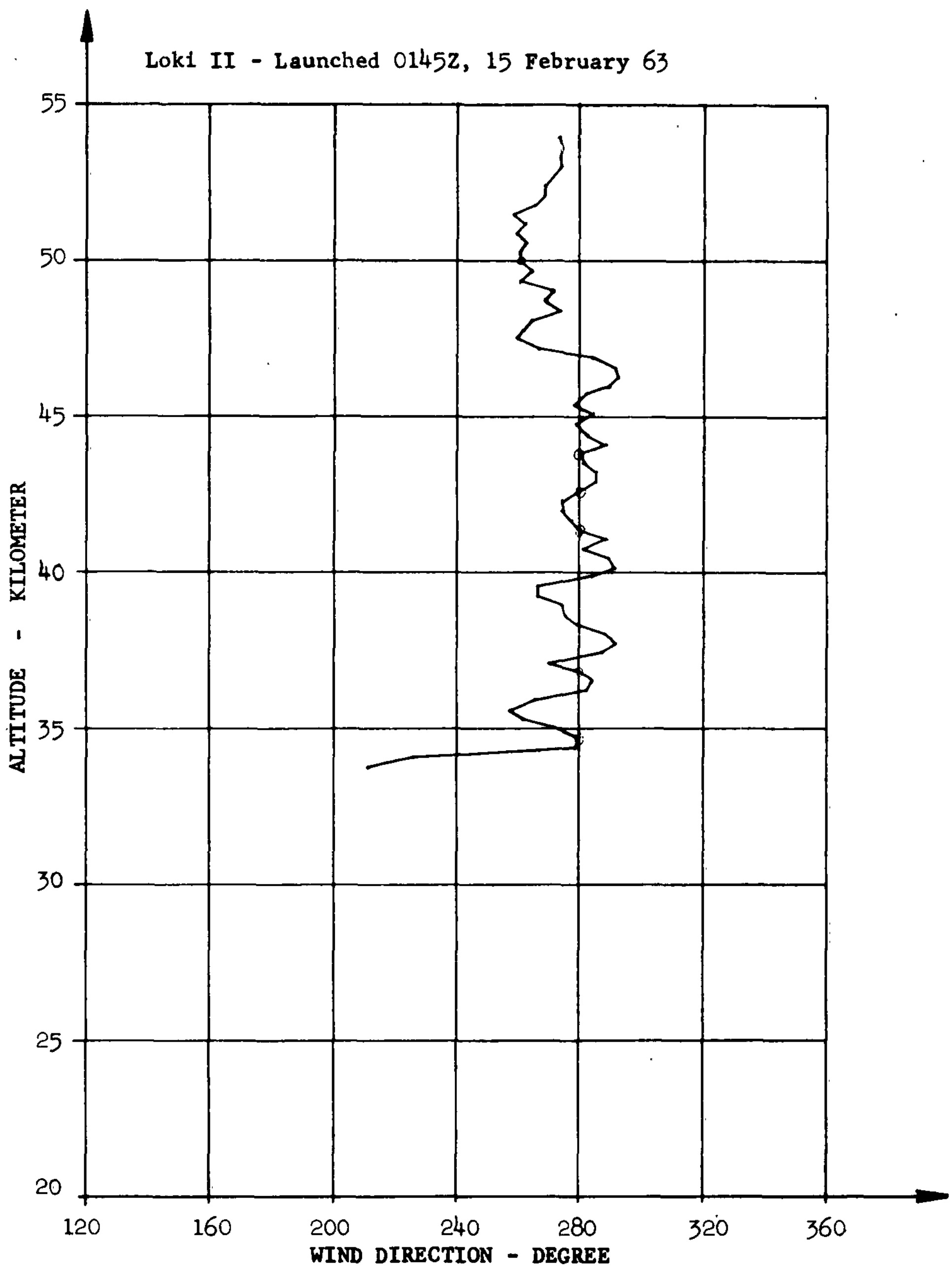

Figure 10. WIND DIRECTION, METEOROLOGICAL ROCKET MEASURED, CAPE CANAVERAL, FLORIDA

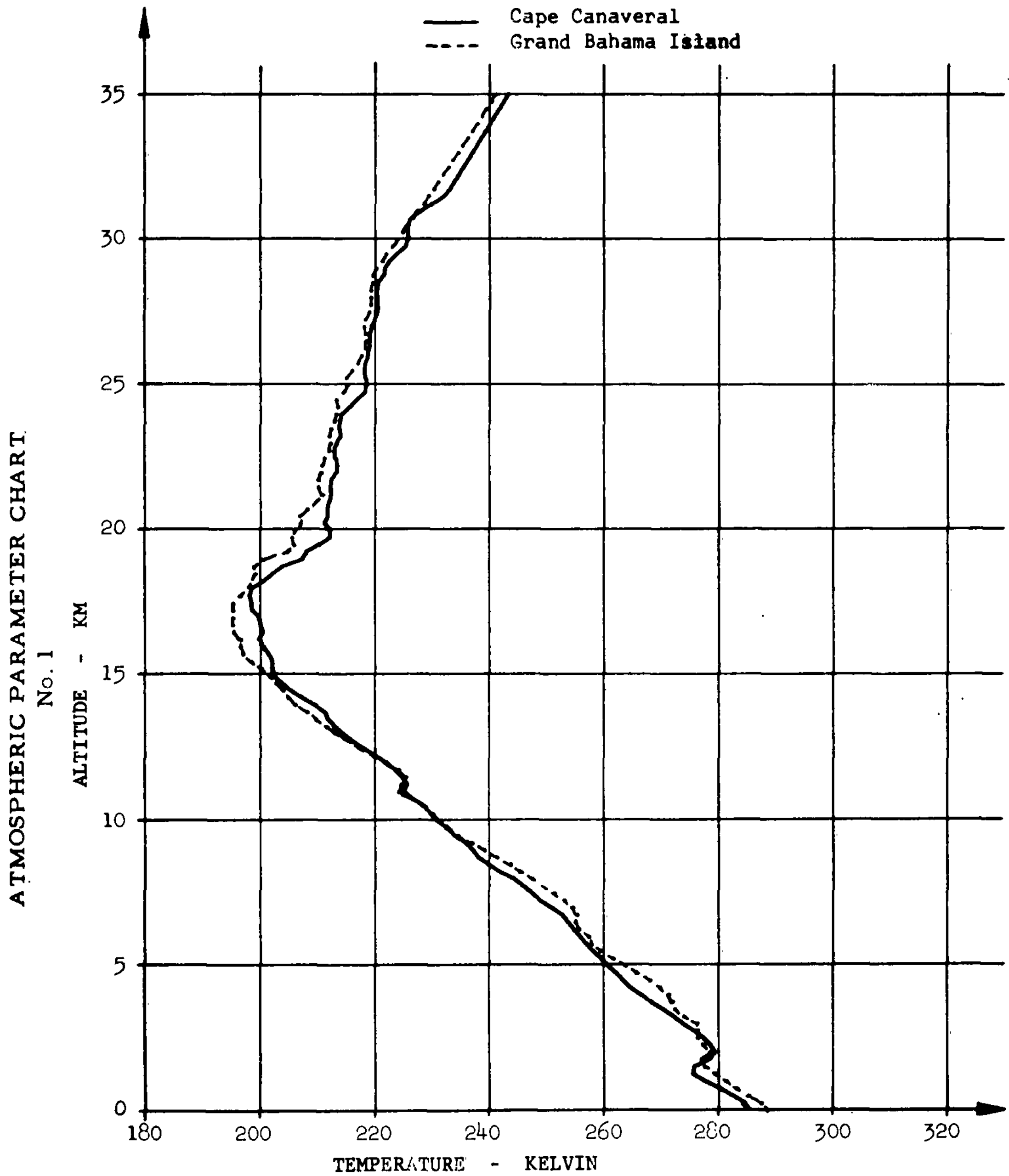

Figure 11. AMBIENT TEMPERATURE, CAPE CANAVERAL, FLORIDA, AND GRAND BAHAMA ISLAND

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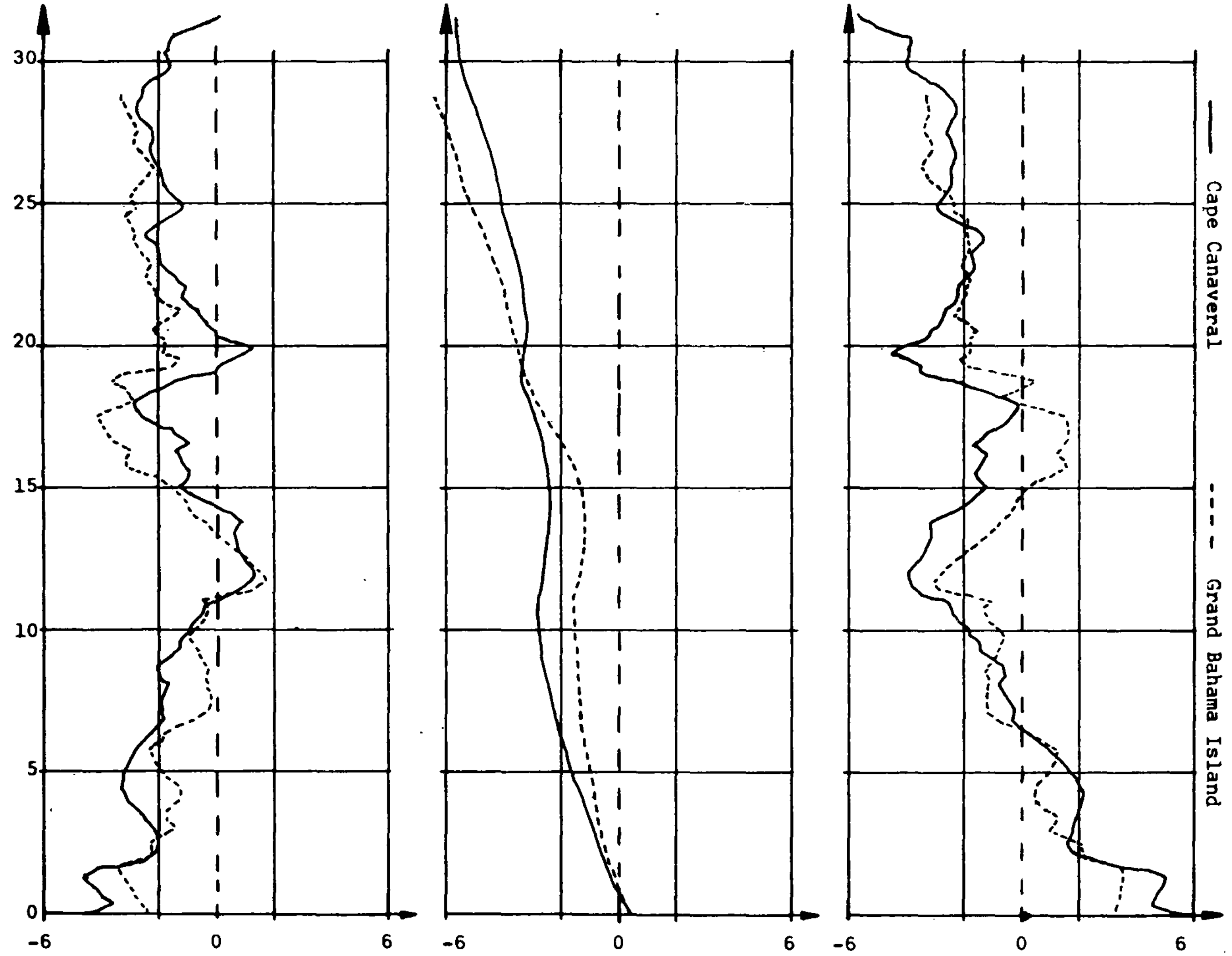

Figure 12. RELATIVE DEVIATIONS OF TEMPERATURE, PRESSURE, AND DENSITY FROM THE PATRICK AIR FORCE BASE REFERENCE ANNUAL ATMOSPHERE

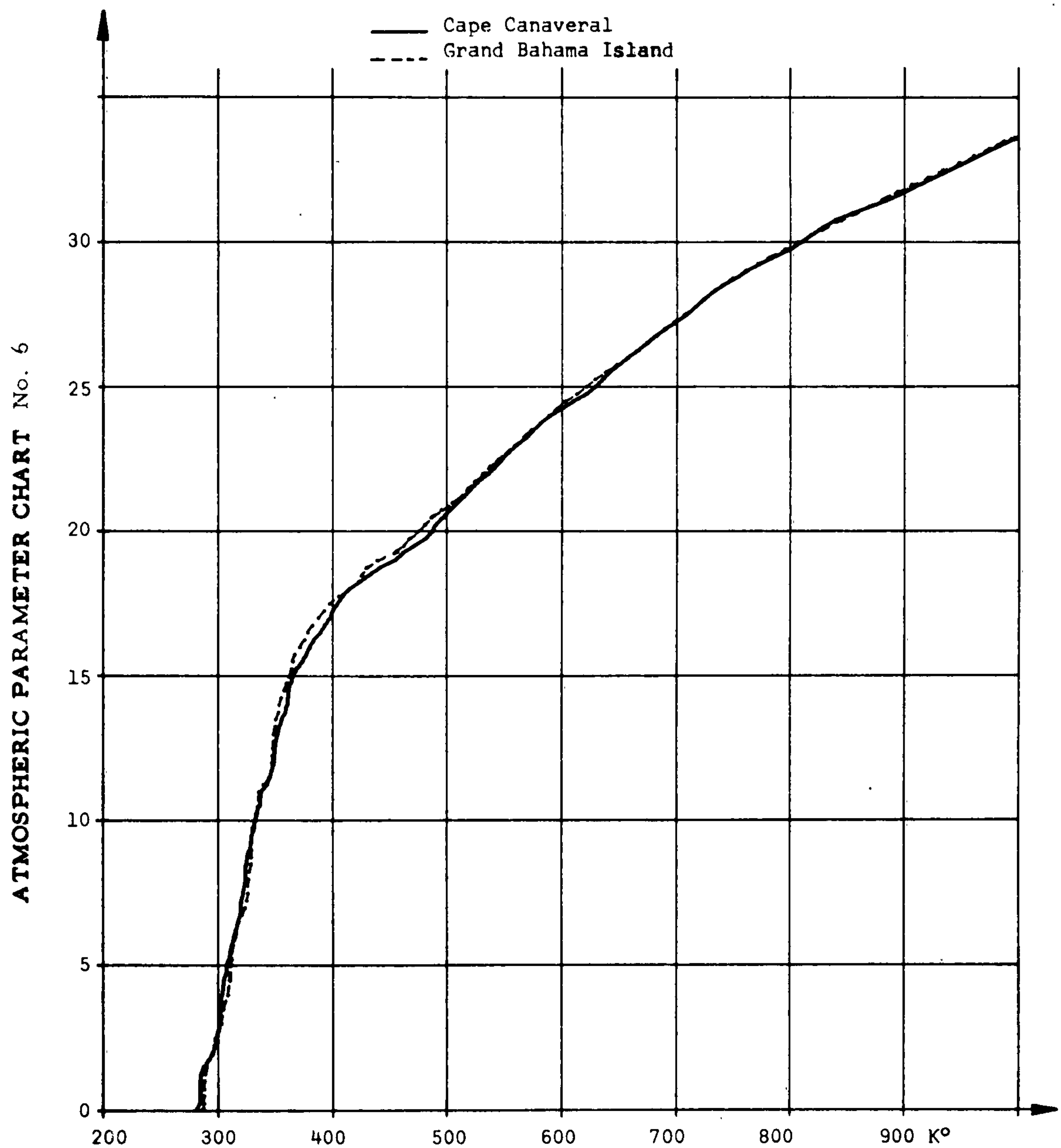

Figure 13. VIRTUAL-POTENTIAL TEMPERATURE, CAPE CANAVERAL, FLORIDA, AND GRAND BAHAMA ISLAND

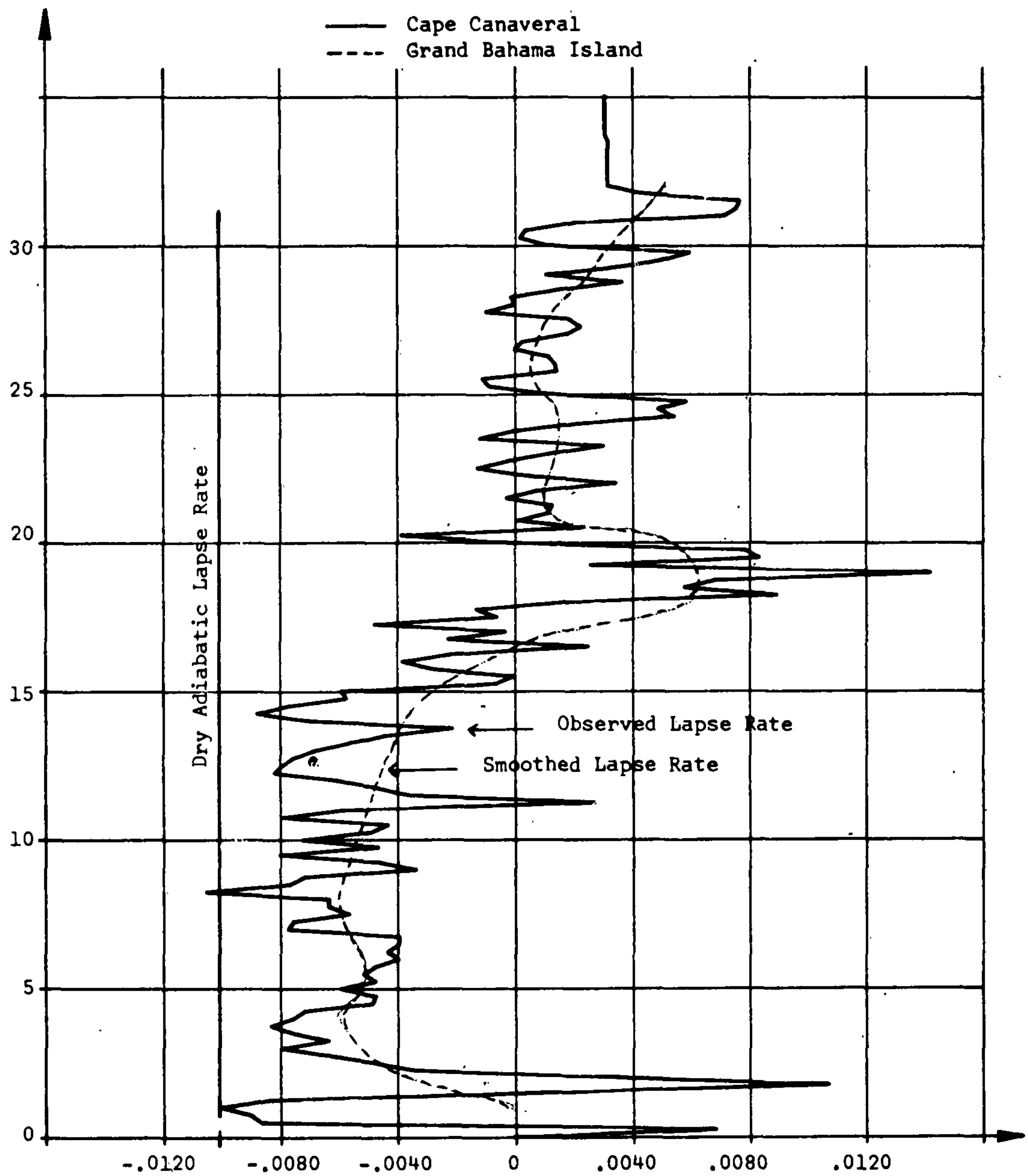

Figure 14. TEMPERATURE LAPSE RATE, CAPE CANAVERAL, FLORIDA

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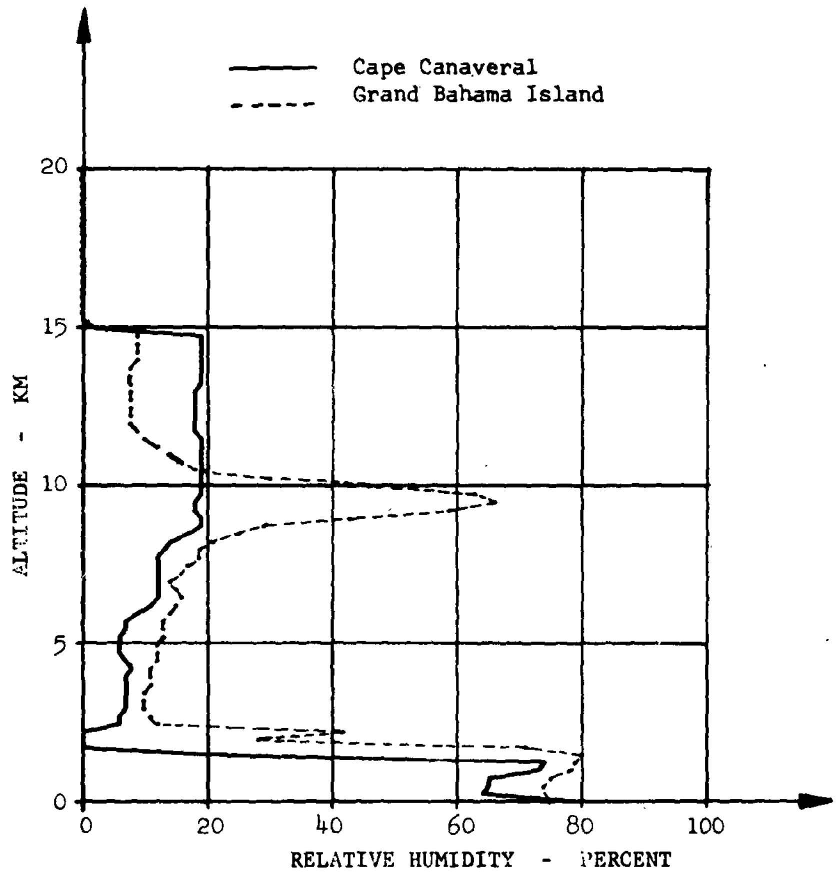


Figure 15. RELATIVE HUMIDITY, CAPE CANAVERAL, FLORIDA, AND GRAND BAHAMA ISLAND

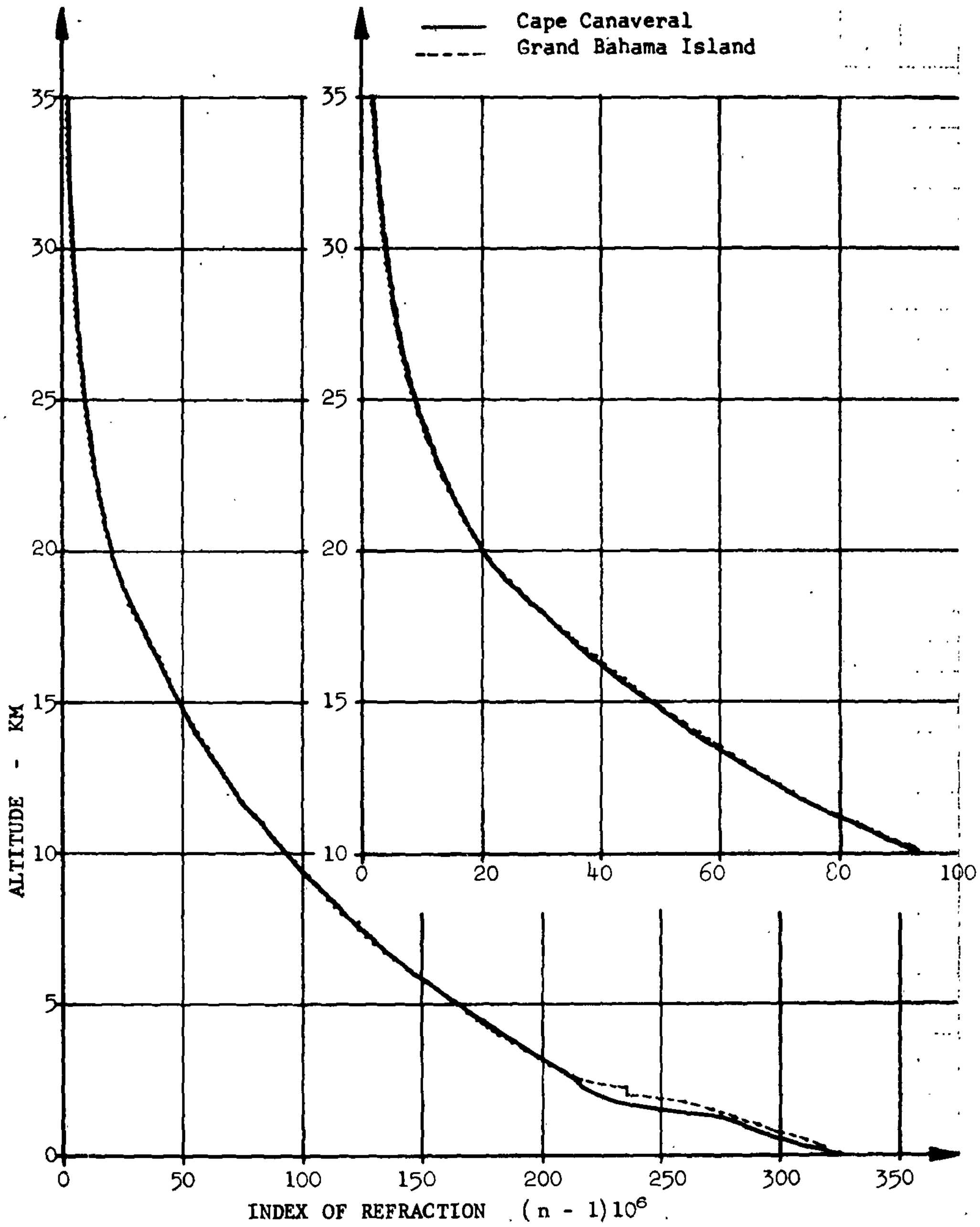


Figure 16. INDEX OF REFRACTION, CAPE CANAVERAL, FLORIDA, AND GRAND BAHAMA ISLAND

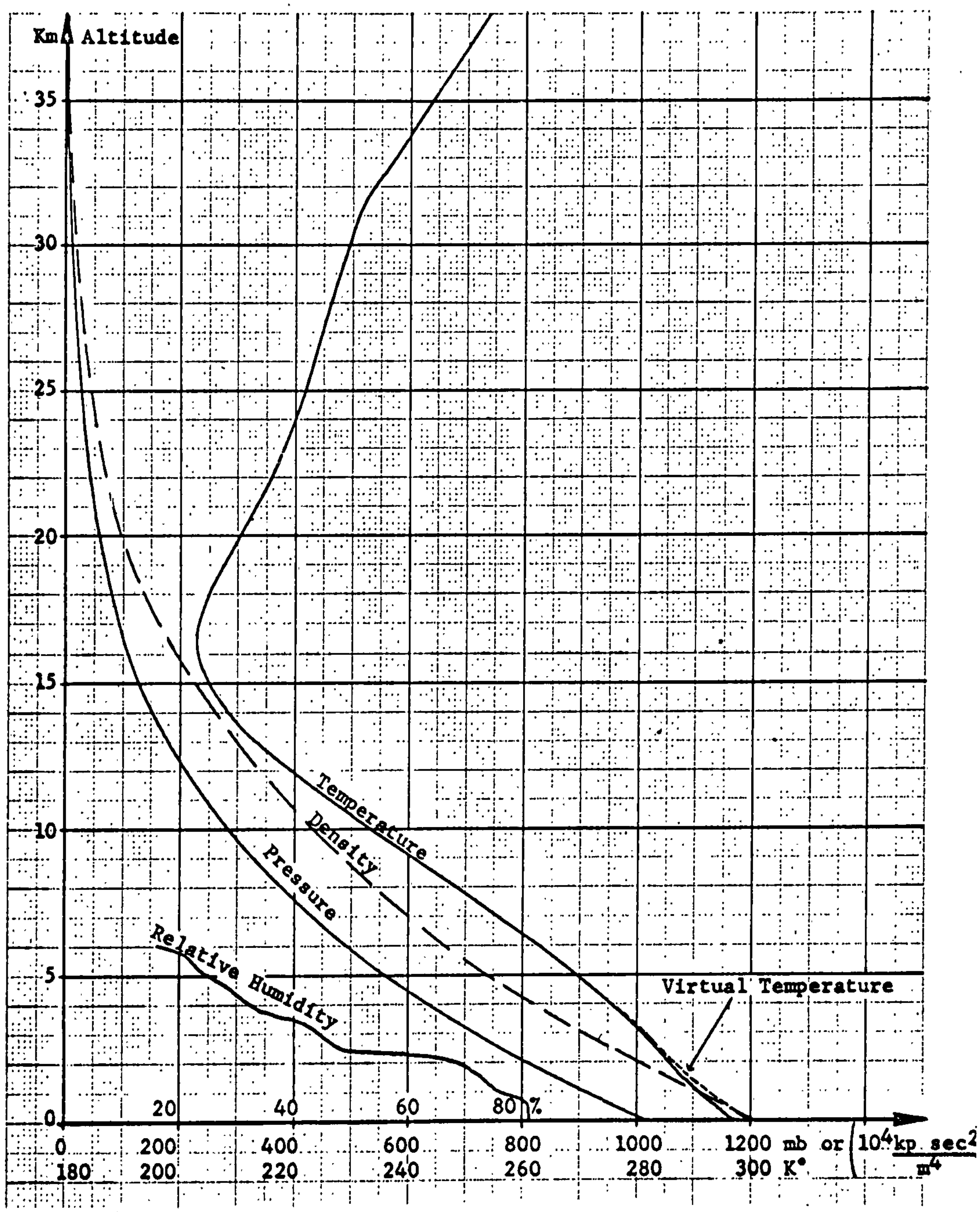
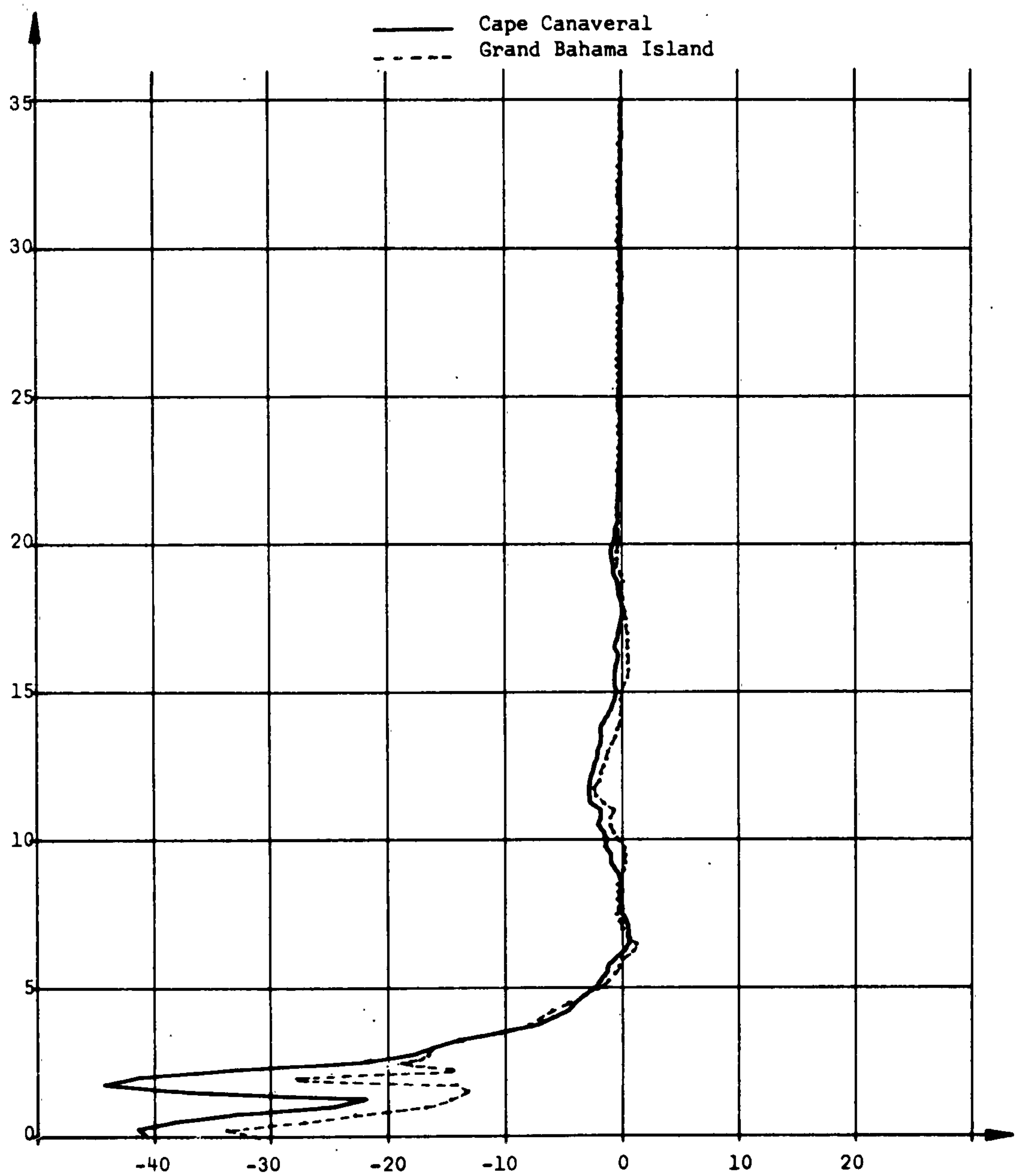


Figure 17. REFERENCE ANNUAL ATMOSPHERE, PATRICK AIR FORCE BASE, FLORIDA



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2. Epstein, R. A.: Analysis of Refractive Index Errors, AFTR No. 2, 1951

3. Smith, O. E.: A Reference Atmosphere for Patrick Air Force Base, Florida (Annual), NASA Report TN-D-595, 1960

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This report presents the atmospheric environment for the flight of Pershing Missile 403, which was launched on 14 Feb 63 from the Atlantic Missile Range, Cape Canaveral, Florida. The general synoptic situation for the flight area, surface observations at launch time, and upper air conditions are given.

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1. Pershing--Atmospheric environment
2. Pershing--Flight test results
3. Pershing--Wind effects
4. Pershing 403
5. Rawinsonde data

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ATMOSPHERIC ENVIRONMENT FOR PERSHING MISSILE-403 - Hubert D. Bagley and Novella S. Billions

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This report presents the atmospheric environment for the flight of Pershing Missile 403, which was launched on 14 Feb 63 from the Atlantic Missile Range, Cape Canaveral, Florida. The general synoptic situation for the flight area, surface observations at launch time, and upper air conditions are given.

UNCLASSIFIED

1. Pershing--Atmospheric environment
2. Pershing--Flight test results
3. Pershing--Wind effects
4. Pershing 403
5. Rawinsonde data

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Correction:

The legend for Figure 7, page 13, should read Cross-Range Wind Components (W_z), Cape Canaveral, Florida, and Grand Bahama Island.

APPROVED

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